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ABSTRACT

This review of the literature on individualized instruction entered in the ERIC system between November 1978 and October 1979 covers the development and sharing of individualized learning modules and systems: mastery learning: applications of television to individualized instruction: descriptive and research reports on individualized instruction-learning: assistance for teachers in the development of individualized courses and topics: a variety of applications of individualized learning in both formal and nonformal educational programs: computer applications and assistance for new users: dissemination of materials for teachers: computer equipment selection: research on various uses of the computer: and the impact of the microcomputer, including a review of current users, software exchanges, hardware system trends, and examples of specific applications. ERIC documents and journal articles comprise the larger part of the bibliography. (MER)

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INDIVIDUALIZED LEARNING USING MICROCOMPUTER CAI

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The literature of individualized learning/instruction systems indicates that these systems work as well or better than traditional, conventional instruction. Students learned more, made higher grades, saved time, performed better on examinations, and felt improvement in self-concept and self confidence. Withdrawals from individualized courses appear about the same as from conventional courses, but a great variability was suggested. Student attitudes toward courses presented in individualized formats were favorable; they liked self-pacing, although lack of self-discipline and motivation caused course-problem difficulties. Learning modules and study guides were found to be helpful and were well received by students; the value of lectures in individualized courses proved uncertain. Learning objectives produced significant increases in learning, while the use of proctors improved the rate of student progress through courses. Retention of learning was improved by individualized instruction, and mastery learning improved performance and reduced forgetting. Students liked self-grading, but reported more was learned with proctor or instructor grading. Test anxiety and grade pressures were reduced with individualized learning, and increased student-staff interaction resulted in higher appraisals of staff.[1]

Five rather broad categories show extensive research, description, and application documentation. These areas include (1) the sharing of learning activities and learning modules, (2) Individualized Instruction in various formats, (3) a continued emphasis on mastery learning, (4) increasing interest in non-broadcast use of television integrated into learning materials and systems, and (5) a rapidly expanding interest in computer-assisted (computer-based, computer-managed) instruction. In each of these, the literature is too abundant to cite, and readers need to see the ERIC Resources in Education for particular titles.

There is an immense literature for sharing both learning activities and developed learning modules. In the ERIC system over the past year (Nov. 1978-Oct. 1979), there are four hundred ninety-four

document entries for learning activities. During that same time, two hundred eighty-two description of learning modules were presented for sharing. These are usually available for importing, amending, and applying at local schools and colleges. Their content ranges the entire educational spectrum. Some descriptions are valuable, some are worthless. Yet if not fully transferable from one institution to another, they represent a wealth of ideas and methods for the local construction of learning modules. They range from full courses of instruction through isolated, single-purpose presentations. While most of the learning activities are oriented to the instructor, approximately two-thirds of the learning modules are aimed at the learner directly, while the remainder present information relating to the development of learning modules. It is interesting to note that consortia have now been formed to develop and share individualized learning materials and systems. Another observation from the literature is the high rate of endeavor among librarians, for there is a wealth of instructional materials presented. Library-oriented materials is designed to serve the student in the library in such diverse interests as bibliographic instruction, orientations to collections, reference resources, or study skills for library use.

Mastery Learning represents another area of further and constant activity in the literature of individualized learning. Forty articles have been indexed in the ERIC system in the past year. These documents generally support the concept that mastery learning significantly improves student acquisition of cognitive skills and reduces variability in achievement within groups.[2] Studies and reports note mastery learning increases both retention and transfer of learning, and favorably affects student attitudes. The literature notes that planning for mastery systems is demanding of instructor time, and recommends a unit-by-unit developmental approach. Studies have been conducted with various learning strategies imbedded in a mastery framework, and bibliographies[3] of the literature are included.

Television is another large category of research and description in the literature of individualized instruction. In the year on which this literature survey is based (Nov. 1978-Oct. 1979) two hundred eight documents on this topic surfaced in the ERIC system. Of these,

nearly half were broad, general observations on the medium. Another fifteen percent dealt with television research, while another ten percent described television viewing habits. About fifteen percent of the articles presented information on instructional television, with another five percent citing evaluations of transmitted telecourses. A limited number of citations fell within the individualized instruction uses of the television medium. Since the "Best of ERIC" report on television,[4] its effectiveness has been assessed,[5] new uses have been noted for individualized instruction[6] and for group instruction.[7] It now serves a broad variety of applications,[8] with some new research thrusts which should provide interesting information for developers of integrated individualized instruction modules. It serves as a nonconventional approach to education,[9] and continues to be studied for both its direct and its incidental learning impacts.[10]

The general ERIC category for "Individualized Instruction" over the past year yields more than one hundred twenty entries. These are, by and large, descriptions of extensive applications in many fields, disciplines, courses, or single-concept modules. This literature is rich with examples, covering all levels of education.[11] The literature is, in fact, so copious that summaries of the research and descriptive documents are now appearing.

Some observer reactions and perceptions of the literature are in order. Documentation in individualized instruction has gone beyond comparative studies of individualized *vs*. traditional lecture-recitation. Some of these are still being done.[12] Current research, however, shows a decline in the literature dealing with the components of successful individualized learning system. No new trends in research are evident from the documentation of the past two years. Four broad perceptions arise from reading descriptive and research reports concentrating on individualized learning. First, individualized instruction-learning is no longer limited to isolated trial and research but is widely applied in classrooms. Second, there is a growing body of materials available to assist teachers in the development of individualized courses and topics. Third, there is an intriguing variety in the purposes for which individualized

learning is used. Fourth, there is a growing interest in computer applications in instruction. Interest in individualized learning is evidenced by the taking up of individualization and the spread of knowledge about it by national teacher organizations, and by the state and federal levels of government. These levels now not only distribute a rationalization for individualization, they also prepare "how to" materials for classroom teachers. Numerous state Departments of Education have sponsored and distributed complete courses of instruction in individualized formats. National teacher organizations hear papers on individualized learning at every annual meeting and regional conference. The American Association for Higher Education, the National Education Association, and the Association for Educational Communications and Technology have prepared publications to assist teachers in the development of individualized systems and instructional materials.[13] Branches of the federal government other than the Department of Education are similarly involved.[14]

Much helpful material is available for teacher training and direct use in module design, development and in implementation of individualized instructional systems.[15] Not only do the traditional teacher organizations provide assistance, but educational institutions have formed consortia with the express purpose of developing, exchanging, and marketing individualized instruction-learning course materials.[16]

With these encouragements, individualized learning is used for a variety of purposes. Instructor-pacing serves to reduce student withdrawals from individualized courses.[17] Schools turn to individualized learning to get more out of the resources available to them.[18] Individualization is used to mold instruction to unique student characteristics,[19] and to permit treatment for "high risk" students.[20] It helps to alleviate course anxiety,[21] affects student attitude,[22] and aids in coping with extensive individual differences.[23] Individualized learning is used in preschool applications,[24] for teleconferencing distance education of Music courses to over a hundred locations in Wisconsin,[25] and enhances correspondence education with telephone tutoring in Sweden.[26] It is not only used with usual on-campus students,

but serves in educational programs for the handicapped,[27] the learning disabled, vocational students, distant learners, and others.

One of the more promising applications in individualized learning, based on frequency of citations in the literature, is computer-related instruction. It shows vigor in the ERIC literature of the past year. Of the 745 entries dealing with individualization, 377 (51%) were computer-related, well ahead of the document activity shown by television-related individualized instruction (208 entries, 28% of total). Entries have appeared in ERIC under CAI, CMI, CBI, and COI (Computer-Aided Instruction, Computer-Managed Instruction, Computer-Based Instruction, and Computer-Oriented Instruction) plus a number of computer-related terms concerning search services, references, simulations, networks, language analysis, education, teacher training systems, conferences, programs, and software.

Computer people have not generally been involved in either PSI or Audio-Tutorial (ICII) activities. While some think in terms of individualized instruction[28] many apparently place themselves in a more limited "computerist" subset. Recent literature, however, shows computer applications out of computer center, in resource centers,[29] "open access" laboratories,[30] and special-purpose computer-based learning laboratories.[31]

What appears interesting in recent computer-learning literature is it's orientation toward assistance to new users. Computer management tools are described,[32] descriptions are available for attention to design of instruction,[33] and the literature even shows how to use the computer to teach computer operations and the required computer language.[34] The documents in ERIC furnish details on using the computer for tests, for assistance in grading student term papers,[35] or evaluating the impact of student entering attitudes on their success in CAI courses.[36] There is data on developing curriculum-information networks for CAI[37] and cooperative computing with other institutions.[38] There is even a self-instruction package to introduce students to the use of computers for research[39] and another self-instruction learning module for preparing computerized ERIC search statements.[40]

Material is available to help with studies for computer equipment selection,[41] developing computer manuals,[42] or how to find out more about computer terminals.[43] The literature provides strategies for production and dissemination of CAI.[44] It provides ideas for the management of a system,[45] orients to available software indexes,[46] provides help in the keeping of student grades,[47] and offers suggestions to make computer materials more transferable for use by others[48] when properly documented.[49] Since the "Best of ERIC on CAI" appeared about three years ago, there have been some obvious new directions in ERIC computer literature.[50] There is an increasing documentation of microcomputer usage in instruction.[51] Yet the microcomputer revolution has not yet strongly impacted the literature - at least not as strongly as known applications in the field would suggest.

Like PSI and A-T research, the research and reports describing computer-related instruction looks beyond generalities and into the effective component parts of a CAI system. While some attention is focused on transferability of developed computer programs, there is not yet much evidence for exchange of computer programs. One can only hope that the use of PASCAL on microcomputers and on mainframes alike will alleviate this.

From observation on our own campus, there is apparently developing a "second generation" of computer-using faculty. They choose not to learn any more about computer equipment than they have learned about videocassette equipment--i.e., how to operate it. They do not intend to learn computer languages or create software, any more than they expect to shoot their own film to use motion pictures. They do not expect to become programmers. They expect to call Audiovisual Instructional Services departments to provide equipment, acquire software - or create it - and set it up at the proper time ready for class use. If programs and hardware are available, they will use these as one more component in their teaching arsenal. They will, under these circumstances, use computers and microcomputers, and send their students to use these aids.

Those who are "first generation" computer users continue to research questions relative to computer uses. There are studies to investigate the effect of immediate vs. delayed feedback from the computer when used by students for computer-managed tests.[52] And there is the inevitable mark of acceptance of computer-related instruction by the academic world - research investigation into the appropriate class size when teaching with CMI![53] Like individualized instruction, computer-related instruction shows an impressive list of descriptions and reports of applications.[54]

Another observation is the increasing number of studies reporting a mix of computer use and television use. When one looks for machine intelligence for the rapid indexing and location of an audio or video frame, one thinks of computers and microprocessors. When seeking storage for an immense number of visual frames, one thinks of video-recording. If intelligent machine indexing and location is married to immense (54,000) frame storage, one is lead to videodisc. It is not at all surprising that videodisc references in ERIC are frequently cross-referenced to CAI.

So, what is it that appears to make the computer, and more specifically the microcomputer, the handiest helper on the horizon for individualized learning. Let's look at the impact of the microcomputer - the personal computer if you please. What can it do, and what is it doing. What changes in the hardware are hitting the markets now, and what do these changes portend? What are our colleges and universities doing, - and California's community colleges. What does it all mean - what can we expect in the 80's?

Computers produce our newspapers, print our books, switch our telephone calls, fly our airplanes, control our manufacturing machines and plants, keep our records, monitor our bank accounts.[55]

Computer use on campuses shows an incredible variety - from drill to modeling to simulation to gaming to graphics to demonstration to data analysis, problem solving, computer assisted instruction, and testing. It is, in short, a remarkably adaptable tool.

It is not entrenched in higher education - it's use is at rather crude levels, considering the sophistication it is capable of handling. Less than ten percent of its use is for CAI. But - CAI use is expanding. 78% of science departments report that they use computers instructionally - and take less than 20% of student course time, even where computer use is rated "extensive". Current faults are that computing is too BASIC, too batch, too slow, too restrictive, and too underdeveloped. Even in math, 64% of computer usage is reported for learning computer languages, for student programming - i.e. less than one-third of available computer time is for learning or applying math![56]

Barriers to computers still exist - lack of faculty training, lack of interest, lack of funds for equipment, and lack of time. Still, the computer is an integral part of higher education in many disciplines. Although not widely used as a teaching aid, interest in its use is growing at a very steady moderate rate. Where used, it is increasingly interactive,[55] and mainframe computing time available for instruction rather than administration is nearly always rated as barely adequate. There is little commercially-available curriculum materials.[56] Experience in teaching is more important in this process than coding. Authoring, coding, and delivery can be as separated as authoring, typing, and lecturing. We've all used typists to help prepare our books - and programmers can be used as experts just as easily.[57] So, if instructional computing needs can't be met by existing computer centers on campus, what is to become of them?[57] They either need to dispense new services, or limit their futures to non-instructional computing. They can, of course, offer assistance for decentralized computers - and for microcomputer users. They can archive data, link, cross compile, share expensive devices, or offer high speed store-and-forward services - not so much because of overflowing microcomputer memories (which will probably be growing as fast or faster than the ease of uploading from micros to mini's). Their value lies in their ability to carry languages and software not available on the micros.

Computer center can be called on for consulting help, conversions, or library functions.[58]

Arthur Luehrmann recently wrote[59] that for the next fifteen years we are going to be experiencing declining enrollments. Schools will have more rooms, teachers and administrators than they need. These are hardly the best times to consider the introduction of labor-saving devices. One consequence of the disappearance of openings for teachers is that change must be brought about through in-service training - so the distribution of materials on how to individualize instruction by teacher organizations becomes even more interesting. Luehrmann also notes a growing evidence that even though school populations are declining, the schools are doing a poorer job of teaching basic skills, and need help in this regard. Furthermore, he notes, as they attempt to educate students with wider ranges of prior skills, abilities and attitudes, schools need more help in tailoring instruction and testing to the needs and developmental level of each student. He suggest the computer as a unique information technology to meet this new need. All prior information technologies have been one-way - but the computer is two-way. It is interactive. It rather naturally lends itself to individualizing management requirements of mastery learning systems.

So, back to the patient drillmaster - the computer. In 1944, the only computer in the U.S. was Harvard's Mark I - a 16-bit, 1000 bit capacity, which cost $125,000.[60] Then came ENIAC - the Electronic Numerical Integrator and Calculator - with 130,000 watts of power. It has been called the world's first personal computer - only a few experts could run it. Today's microcomputer is more powerful. Apple, for example, is about five times as powerful as ENIAC, yet uses only about 50 watts of power, is about 18 inches square, runs cool, weighs about 11 pounds, and can be used by almost anyone.[61] Personal microcomputers today are at about the same stage of development that television was in, during the late 40's, or color television was in the late 50's. They are being marketed at over 30,000 per month - more than 300,000 units this year.[62] This explosive growth is being

experimented with - in a variety of ways. Micros can use existing time-sharing networks, and can download programs in which micros are used as intelligent terminals on larger, host machines. A recent USC study[63] suggests that in less than ten years from now, 50% of American homes will have a personal microcomputer - more than 40 million units by 1990. Right now, the study shows these microcomputers are being purchased by 20-45 year old, middle class males, 70% of whom have B.A. degrees - and almost all of them are self-taught on computers. On the average, they paid $4,500 for their systems, and nearly 80% of them are used in work-related circumstances. But, the market has been shifting to small businesses and the professions for the past two years, and educational purchases have hardly begun.

Schools today speak of "computer awareness" or "computer literacy", and microcomputers are being introduced into all kinds of everyday classroom experiences.[64] Their cost has dropped markedly. Teachers without prior computer experience are using them, and education is changing as a result. Although their first use in schools has frequently been to do extensive computations, they are capable of much more. They can draw pictures and make music. They can drill in rote memorization, tutor in all subjects, or simulate in areas too costly or too dangerous to experience in real life. And they can store, sort, and retrieve large amounts of data with ease, speed, and accuracy. The market for these machines will increase about 8 fold in the next 5 years. They are no longer the "thinker toys" of the computer hobbyist, who now accounts for only about 10% of the market. By 1985, 55% of the sales will be to "establishment", and another 40% will be over-the-counter consumer sales. All of this from an industry in which 60% of the computer stores open today are less than a year old.[65] So - expect in the future that many of your students will be able to do their computer homework where homework was intended to be done - at home! If appropriate drill is prepared by the teacher, and records management and testing is done by a

classroom microcomputer, teachers will be free to emphasize concepts and understanding - and drill can be individualized according to need.[66]

The hardware systems of microcomputers are still changing. 64K bubble memories are now available, which are very fast. They are now made by 5 companies, but 3 more are supposed to enter the market this year.[67] Last year a quarter of a million 8" disk drives were manufactured, along with half a million 5" disk drives. There should be over a million 5" drives this year, with 30% of those being able to read both sides of a diskette.[68] Japan is now manufacturing 5" drives, so about a one-third price drop is expected by some.[69] Texas Instruments has formed a joint venture with Sony - which means it will be color capable, as is the new Radio Shack TRS80 Color, or TRS90.[70] TI already has a sound synthesizer which can store a vocabulary in memory, and another 180 in ROM or Read Only Memory. Another new system uses 62 phonemes, or sound units, which can be combined to form an unlimited number of words. Even IBM has a talking typewriter.[71] And memories are getting bigger in micros. Nestar has a 33 megabyte memory which can cluster 64 microcomputers into one system. Micros in these kinds of systems can stand alone, or upload for more memory.[72] Circuit boards are on the market to tie an Apple microcomputer to a VHS or Beta television cassette recorder.[73] So microcomputers now have the capability of linear video storage - but perhaps not yet as flixible as videodisk. And Bell and Howell is going into software. It's generalized Instructional Systems includes an authoring system which allows teachers to create their own materials readily, - and get grade reports, or control class enrollment. Furthermore, unlike most systems which acknowledge mistakes with a SYNTAX ERROR statement, the Bell & Howell GENIS system is reported to understand misspelled words.[74] All of this adds up to hardware which costs less and does more. As prices drop, microcomputers will continue to proliferate. And the necessity of addressing the questions of computer awareness or computer literacy becomes more apparent.

What are the colleges and universities doing with microcomputers today? Generally, you can break this into two functions - teaching

computer languages and teaching other things. Almost every computer language currently popular, from BASIC to FORTRAN to COBOL to PASCAL - will work on one or more, if not all, microcomputers. Other languages are also available, but various dialects of these are most popular. So let's look at Micro CAI for teaching other subjects. Among other things, if you were one of the 18,000 persons expected to attend the 5th West Coast Computer Faire in San Francisco, March 14-15, you could have struck a blow for computer awareness and taken a UC Extension course on Microcomputers in Education![75] And if you had attended Golden Gate University last year, you could have become a member of the first group in the United States to graduate with an M.B.A. - telecommunications degree.[76] If you plan to attend the 58th Annual Meeting of the National Council of Teachers of Mathematics in Seattle in mid-April, you'll find at least one computer session being held during every time slot.[77]

Of course, there are courses on many campuses which use computers as an adjunct to the discipline. Some, like Simon Fraser, use the computer to teach the discipline - in this case chemistry.[78] Computer applications are not a supplement, but are integrated into the instructional process - with the result that failures have been cut to less than one percent D and F grades, compared to 5 to 10 percent in traditional instruction there. Similar integrations of computer applications can probably be found on most college and university campuses today. So lets look at some of the wide variety of other microcomputer uses.

The University of Wisconsin simulates a network of 200 microcomputers - although they use a mini computer to do it.[79] Since they expect the personal computer of tomorrow to have the power of today's mini, perhaps it doesn't matter. They're also researching syntactic and semantic error detection and correction - field testing a PASCAL compiler with error correction to make programming easier for non-technical people. They hope to improve programmer efficiency, since the cost of programmer time becomes relatively more expensive as the cost of hardware drops. They're also researching the computer-video disk system for still-and dynamic computer graphics. And they're

interrelating micro to mini hookups for distributive computing - running interconnected tasks simultaneously on separate machines.

The Ohio OCLC consortium operates a nationwide network of 3000 terminals in 2000 libraries in 50 states. They are now going into "Channel 2000", a computer-based information network to use a home micro and television set and a telephone into a bill-paying bank service, a library catalog, an encyclopedia, and a community information service. Its a first for electronic transfer of funds and for electronic publishing in the U.S., as well as the first encyclopedia available to home terminals, and the first interactive banking in the U.S.[80]

As a state, Minnesota has shown an impressive attention to microcomputer CAI. The Minnesota Educational Computing Consortium (MECC) says there are over 25,000 microcomputers in use in education now, and estimates that there will be 100,000 by 1982. This system provides 2,000 terminals on large computers, and places Apple microcomputers in classrooms. About 10% of the school districts in the State now use microcomputer CAI, and as of the first of this year, the use was expected to increase to 50%. Half of all MECC programming is in BASIC, and is very transferable on floppy diskettes. Most of these programs are keyed to a minimal microcomputer system - an 8-bit microprocessor, keyboard, and either a printer of CRT, and only 12K of memory other than the language requirement.[81]

Two years ago Minnesota had some good data on the cost of using microcomputers - data from 200 schools using 700 Apples, about 3/4 of which are in elementary and secondary districts. MECC reports costs of 10¢/hr. for math in grades 106, 50¢ per student hour in bilingual education.[82]

Another software exchange source is CONDUIT, at the University of Iowa. It is funded by FIPSE, is converting about 35 micro CBI modules in a variety of disciplines. These are tested modules, very well received on our campus, at least.[83]

There are many more interesting microcomputer applications around the country by colleges and universities. SUNY-Stony Book uses PET's to teach programming in minority high schools, checking microcomputers out to students for homework. Message systems on micros are being developed by the University of Wisconsin. M.I.T. has a project to teach teachers in microcomputer math and science. NSF is funding studies of the intelligent videodisk at the University of Utah. Harvard requires an elementary acquaintance with computers, and freshmen must demonstrate their ability to handle computer-related skills.[82] Teacher's College at Columbia University has a Microcomputer Resource Center for teachers who want an introduction to microcomputers and related equipment.[84] Oregon, Cal. Northridge, and Stanford are all working on computer misc. improvements.[85] Similar reports show microcomputers used for handicapped (U. Penn.), in lecture halls at the University of Georgia, for patient education at Minnesota Graphic College, Math at Milliken, Nursing at Texas Women's, etc.[86] These last are all reported from the Apple Education Foundation.

In California, Stanford, the Lawrence Hall of Science, and the California School For the Deaf have been using 60 Apple microcomputers with 1,000 lessons in BASIC,[87] concluding that students learn as well from microcomputers as they did from computer terminals, without the related problems of phone costs, terminal placements, or computer down time.

California's Community Colleges recently reported on their use of CAI.[88] Of 106 colleges surveyed, and 87 responses, 48 have some CAI on campus, 39 do not. 29 colleges have CAI in a single department, generally computer science or math or business. 5 colleges reported CAI in 4 or more departments - the category for Cabrillo College, where we have CAI in Food Services, Physics, Chemistry, Math, Computer Science, Music, Electronics, Business, and Biology. In our Individualized Learning Center and Computer, students can use microcomputers and have access to over two hundred computer programs in a broad variety of disciplines.

Elsewhere in California Community Colleges, there is an impressive array of microcomputer applications. Fullerton has a project using a microcomputer coupled to video monitors for classroom display of fixed or moving full color diagrams, pictures, charts, maps, graphs, tables, or statistical reports.[89] Santa Ana College has a micro CAI Microbiology. Columbia Community College uses microcomputers for problem solving in math classes. San Francisco City College has an in-service program to train faculty in microcomputer usage, and has an extensive microcomputer applications in chem labs, and a microcomputer music aid known as MAMA. Yuba College employs micros for independent study computer science courses. Allan Hancock College is engaged in a faculty computer literacy project, while Evergreen is seeking to use micros for records management for an individualized communications skills project which it hopes to extend to math and science. Grossmont has computer projects in reading and vocabulary learning, While Chaffey has an impressive array of modules in Psychology.

Many of these community college CAI efforts will result in additions to an exchange library under development. UC Santa Barbara hosts the Instructional Improvement Information System, IIIS, which data bases instructional projects and products from the campuses of the University of California system and the California State University System. In operation since 1976, IIIS took in the community colleges in 1978, is planning on the addition of the Association of Independent California Colleges and Universities. Currently serving 133 campuses, this addition will bring an instructional improvement information file to 190 campuses serving over two million students. The system is being copied in other states, and the possibilities of funding a national data base is under discussion with N.I.E.[90]

Information on instructional improvement and the impact of CAI is so extensive that a broad expansion of authority to use <u>all</u> instructional technologies is before the California Legislature as an Educational Telecommunications Bill(AB3303).[91] So CAI is alive and well in the colleges and universities.

What can we expect in the 80's? Expect the personal computer to increase in it's computing power, in it's memory size, in it's speed, and in numbers - while dropping in price - a microcomputer more potent and infinitely less expensive than the minicomputer systems of today.[92] Anticipate that in the future nearly every viable computer language will be available on micros, including languages compatible with IBM equipment[93] and even a major extension in availability of IBM microcomputers.[94]

In the press to get campus computer uses off IBM cards and onto CRT's, to cut paper costs, reduce turn-around time for students, make students more independent learners in computing, and allow students to carry their memories with them, expect an increase in applications of CAI on microcomputers.

For larger systems' CAI,[95] look for expansions in incremental compiling, virtual memory, and speeds so fast that they appear as time-sharing interactive although they may in reality be simply incredibly fast batch modes. Anticipate more distributive computing - micros to minis to macros - more computer-to-computer interfacing. Expect structured domputer languages - over 400 colleges and universities report using PASCAL - and there is a strong movement to structure BASIC to improve the power of the language. Most of these future systems will be self-documenting, require less flowchart documentation, and easier to program - i.e., within the grasp of classroom teachers. Couple these projections with the impact which can be expected from increasing numbers of "personal" microcomputers in homes, offices, businesses and schools, and one might well conclude that the future for CAI is indeed promising.

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